FUNGI AS CONSTITUENTS OF GUT CONTENTS IN SMINTHURIDAE AND DICYRTOMIDAE (COLLEMBOLA)

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ГРИБЫ КАК КОМПОНЕНТЫ СОДЕРЖИМОГО КИШЕЧНИКА КОЛЛЕМБОЛ СЕМЕЙСТВ SMINTHURIDAE И DICYRTOMIDAE (COLLEMBOLA)

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Fungi often occur in the guts of many collembolan species, particularly forest litter dwellers. Sminthuridae are considered to be large phytophages. Some of them are pests of cultivated plants, e.g. S.viridis. The present study is concerned with the nutrition in seven atmobiotic collembolan species of the suborder Symphypleona.

The collembols under investigation are the most common is the study area. The species Heterosminthurus insignis, Dicyrtoma fusca, Ptenothrix atra, Ptenothrix leucostrigata, Sminthurus fuscus, Sminthurus viridis were collected from the litter in forests of the Kalinin and Moscow Regions. Smithurus multipunctatus from grasses in the clayey semidesert of the northern Precaspian, the Ural Region.

The range of diet constituents was revealed, using crushed preparations of isolated guts by a modified method.

The percentage of different objects revealed in the guts of each individual was estimated from the ratio of areas (measured in square microns) occupied by them on the preparation. The total area of the objects on the preparation was assumed to be 100 per cent. In contrast to the above study, the entire crushed preparation was examined, but not several selective fields of vision. This procedure permitted estimating the absolute values of the total length of hyphae and number of spores occurring in the guts. For every species no less than 10 individuals of the same size class were examined. The average percentage of diet constituents is given per one individual and designated as C. The occurrence of food objects (O) is expressed in percent of the total number of individuals examined (Table).

The rate of the passage of food through the gut was estimated under laboratory conditions at 18°C in starved collembols P.atra and P.leucostrigata. If the fruit bodies of Basidiomycetes whose spores have a shape characteristic of the given fungus are used for food, these spores can be used as markers since in contrast to the fungus body they pass through the gut unchanged. For that purpose, the fruit bodies of Trachypus scaber were used. Five parallel experiments were performed for each species maintained singly in Petri dishes on the bottom of which water-soaked filters were placed. The observations were performed under the binocular under low light intensity natural light. As they were excreted, the feces were carefully removed with a preparing needle and crushed preparations were produced to be immediately examined under the microscope to fix the moment when the marker spores appeared in them and thereby determine the time (T) of the passage of food through the gut. To understand the mechanical changes of food objects in the species P. atra and P.leucostrigata in the course of feeding, the gut contents were compared in collembols fed with the fruit bodies of pore and gill basidium fungi (Trachypus scaber, T.versipellis, Russula so.) with freshly produced feces. In addition, a culture of Penicillium sp. was used for a diet in the same experiments.

The gut volume was estimated by measuring its length and diameter on histological sections prepared, using a conventional technique. No allowance was made for the inevitable deformation of the gut during fixation and subsequent treatment when preparing the sections.

In the guts of the species under study a wide variety of diet constituent was recorded, including hyphae and spores of various fungi, varied algae, fragments of epidermal and mechanical tissues of higher plants, mosses (e.g. sphagnum), pollen of arboreous and herbaceous plants, Protista, mineral particles and amorphous mass. Fungal mycelium and fungal hyphae are present in the guts most frequently and in considerable quantities (Table). The proportion of plant materials is much lower.

Among numerous mycelium varieties, dark coloured 5 μ in diameter prevailed. The total length of hyphae in an individual with a fully filled gut may attain a considerable value, e.g. in H.insignis, P.atra, S.multipunctata it is respectively 30.5, 24.2 and 9.7 mm, while this index was much lower as estimated on an average per individual of the above species, 4.3, 10.0, 2.3 respectively.

Over 20 spore species (both monocellular and multicellular) and a large number of pycnids were revealed. In the guts of individuals collected in natural habitats largely dark-coloured spores occurred, many of which were identified. Among them, the spores of Fungi imperfecti were revealed from the two orders Hyphales (family Dematiaceae, genera Alternaria, Curvularia, Monodictys, Cladosporium, Stemphyllum, Thielaviopsis, Helicoma, Trimatostroma, etc.) and order Sphaeropsidales.

Fungi imperfecti of the family Dematiaceae were found on the examination of the other species of Collembola.

In forests, the bulk of dark-coloured fungi occur on fresh fallen leaves and in the upper horizons of the litter, particularly, in the L- and F-layers. This is the place where the species of the atmobiotic group are concentrated.

Along with plant tissues and pollen, fungi were also found in S.viridis. In another species of the same genus S.multipunctatus collected from grasses the guts revealed considerable quantities of spores and mycelium (Table). In nature, the feeding individuals of this species scrape the surface of the stalks and leaves of plants. Examination under the microscope has revealed that the tissues of plants on which the collembols were feeding permeated with a dense network of mycelium with pycnids and other reproductive organs. Presumably, collembols select those plants on which epiphyte and parasite fungi are located. Thus, the attribution of S.viridis to phytophages has to be supported. Possibly, this species is a secondary pest attacking cultivated plants that have been already affected by fungi.

Percentage composition (C) and occurrence (O) of the components in the gut contents of Collembola in different seasons (I - spring, II - summer, III - autumn)

Study area (region)	Kalinin				Moscow						Ural	
Species name	H.insignis				D.fusca		P.atra		S.fuscus		S.multi-punctatus	
Time of observations	I		III		III		II		III		I	
	C	O	C	O	C	O	C	O	C	O	C	O
Gut contents												
Hyphae	10.0	79	14	91	45.7	88	16.2	96	0.6	84	17.8	92
Spores and reproductive organs	9.4	52	34.9	83	0.2	66	23.4	78	87.0	84	60.3	94
Algae	+*	7	5.7	25	0	0	+	2	+	3	0	0
Pollen	21.0	76	+	83	0.3	38	4.0	65	1.9	71	2.2	76
Plant tissues	+	5	14.5	52	1.0	17	29.3	31	+	10	3.0	20
Amorphous mass	59.6	100	30.7	95	52.8	100	27.1	100	10.1	89	16.7	94
Number of individuals examined	15	42	15	64	20	24	15	49	15	63	33	71
Biotopes	bog pine forest						birch forest		pine forest		steppe	

* < 0.1%

Collembols often occur on the fruit bodies of Basidiomycetes. The guts of the individuals collected from them are completely filled by the fungal body and by its spores. In fact, in P.atra (on the average for 15 individuals under investigation), fragments of the fruit body constituted 90.8%, spores 7.6%, and in P.leucostrigata 93.4% and 6.5%, respectively.

An experiment with these two collembolan species has revealed that they feed on the same parts of the three basidial fungi offered to them, process them in the same manner. The feces are a homogenous mass in which only the spores that are unchangeable externally are well-defined, as well as separate fragments of the hyphal sheathes. The spores fof Penicillum sp. do not lose their germination capacity and germinate after 24 hours. Analogous results have been obtained in analysis of the feces of S.multipunctatus feeding under natural conditions (100 fecal pellets were examined). But in addition to the fragments of hyphal sheathes, there occurred macerated fragments of plant tissues and spores, and some of them were destroyed.

The volume of the gut (in mm^3) was calculated for the following species: S.multipunctatus, 0.115; S.viridis, 0.069; P.leucostrigata, 0.035; H.insignis, 0.010; S.aquaticus, 0.002. T has been determined for P.atra and P.leucostrigata. The first marker spores appeared in their feces 2 hours after the beginning of feeding, and 3 hours later they occurred in large quantities. Under laboratory conditions, collembols can feed almost constantly during the day.

Knowing T, one can assume that the gut is refilled 8 times daily, and thereby the volume of the substrate passed through the gut of a single individual during that time can be estimated. For example, in P.leucostrigata, this value is 0.28 mm^3.

With data on collembolan number in nature available, and with estimated T, gut volume, the quantity of consumed mycelium, etc. one can assess quantitatively the contribution of the species under study to forest litter decomposition.

R e f e r e n c e s

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D i s c u s s i o n

Betsch J.-M.: 1. Have you observed that same food material can be ingested by two different Collembolan species? If so, did they digest the same part of the ingested material?

2. You show a micrograph of a very young Dicyrtomid, first or second instar. Have you observed differences in the food spectrum on the different instars of the same Collembolan species?

Nadtochiy S.E.: 1. Yes. Comparing gut contents and fecal pellets of P.atra and P.leucostrigata fed on fructification bodies of basidium fungi we can say that the species feed on the same structures of the offered fungi (Trachypus scaber, Russula sp.) and similarly change them mechanically.

2. It is known that the food composition of different instars of the same species might change. The collected material was not sufficient to compare food spectrum of different instars of the same collembolan species. The largest individuals of each species from one size class were examined.

Zinkler D.: Sminthuridae ingest mainly fungi mycelia and spores! How the animals gain the intracellular compounds? The hyphae are destroyed mechanically by mouth parts or by enzymes? Did you find hyphae in the pellets? The same questions to the spores respectively.

Nadtochiy S.E.: Hyphae and spores are not destroyed by mouthparts of Sminthuridae. While fecal pellets of the individuals collected from Basidiomyces contain damaged hyphae (their sheathes) and unchanged spores. Fecal pellets of Collembola collected from the forest litter often contain both dark coloured damaged hyphae and spores without inner contents and unchanged. So some types of mycelium and spores are digested while others do not. But much data should be obtained to make some conclusion.

Haq M.A.: Your experimental species is from lab. cultures or from the field populations?

Do you think your species is microphytophagous?

Have you verified it by laboratory feeding experiments?

Nadtochiy S.E.: The investigated species of Collembola were from the field populations.

May be better consider them mixedfeeding species. Tissues of higher plants are often present in their guts.

The aim of our work was to examine the diet of the species from their natural habitats.

Dallai R.: Why you have said the structure of the midgut cells is different in the two Sminthuridae you have showed? Do you think the difference concern only the highness of the epithelium or do you mean differences are in the structure of the cytoplasm of the cells?

2. The second question should been to you concerns the food of Sminthurus viridis. You said that this species is a secondary pest or usually it eats fungi. But you said also fungi are not digested. So, which are the energetic sources of the species?

Nadtochiy S.E.: 1. It was clearly seen on the slides that midgut cells of the two species differ in their highness. But this is only a preliminary observation. Special work should be carried out to find if there are differences in the structure of the cell cytoplasm.

2. Some fungi in the collembolan guts are destroyed mechanically (this is clearly seen on the preparations). But we know little about how the food is changed chemically in their guts. Which are the energetic sources of Collembola - this is the problem to all collembolists, and it is now far from being solved.